Claims

1. A position encoder comprising:

first and second members which are relatively movable along a measurement path;

an excitation winding and a sensor winding, at least one of which is carried by the first member;

a magnetic field generator carried by the second member and operable to generate a magnetic field which varies with position along the measurement path;

a film of magnetisable material which is located, in use, within said position varying magnetic field to cause the film to have a positionally varying magnetisation state along the measurement path;

wherein the excitation and sensor windings are arranged relative to said film so that a mutual electromagnetic coupling between them varies in dependence upon the positionally varying magnetisation state of said film of magnetisable material, so that when said excitation winding is energised with an excitation signal, a sensor signal is generated in said sensor winding that varies with the relative position between said first and second members;

an excitation circuit operable to generate an excitation signal for energising the excitation winding to cause the excitation winding to generate an excitation electromagnetic field which interacts with said film of magnetisable material in a non-saturating manner in the vicinity of said sensor winding; and

a processing circuit operable to process the sensor signal generated in the sensor winding in response to the energisation of said excitation winding, to determine a value indicative of the relative position between the first and second relatively movable members.

2. A position encoder according to claim 1, wherein said excitation electromagnetic field comprises a first component which is orthogonal to the surface of the film and a second component which is parallel to the surface of the film and wherein the excitation winding and the excitation circuit are arranged so that the magnitude of said second component is insufficient to drive the film into and out of saturation in the vicinity of said sensor winding.

3. A position encoder according to claim 1 or 2, wherein said excitation winding is arranged relative to said film so that said excitation electromagnetic field is substantially perpendicular to the film along the measurement direction.

4. A position encoder according to any preceding claim, wherein said excitation circuit is operable to generate an excitation signal having an excitation frequency and wherein said processing circuit is operable to process a sensor signal generated in the sensor winding which is substantially at said excitation frequency, to determine said value indicative of the relative position between the first and second relatively movable members.

5. A position encoder according to any preceding claim, wherein said magnetic field generated by said magnetic field generator creates an in-homogeneity spot in said film, the position of which varies with the relative position between the first and second relatively movable members and wherein said excitation and sensor windings are arranged so that the mutual electromagnetic coupling between them varies in

dependence upon the position of said in-homogeneity spot in the film.

6. A position encoder according to claim 5, wherein said in-homogeneity spot comprises an unsaturated region of the magnetisable material surrounded by a saturated region of the magnetisable material.

7. A position encoder according to claim 5 or 6, wherein said in-homogeneity spot is created at a position in the film where the magnetic field generated by said magnetic field generator is substantially perpendicular to the film of magnetisable material.

8. A position encoder according to any preceding claim, comprising first and second sensor windings that are separated along said measurement path and which are arranged so that when said excitation winding is energised with said excitation signal, a respective sensor signal is generated in each sensor winding that varies with the relative position between said first and second members, and wherein said processing circuit is operable to perform a ratiometric calculation on the sensor signals generated in said first and second sensor windings to determine said value indicative of the relative position between the first and second relatively movable members.

9. A position encoder according to any preceding claim, comprising a plurality of excitation windings each operable to generate an excitation electromagnetic field when energised by said excitation circuit, wherein each excitation winding

and the or each sensor winding are arranged relative to said film so that a mutual electromagnetic coupling between them varies in dependence upon the positionally varying magnetisation state of said film of magnetisable material, so that when each excitation winding is energised with an excitation signal, a respective sensor signal is generated in the or each sensor winding that varies with the relative position between said first and second members and wherein said processing circuit is operable to perform a ratiometric calculation on the sensor signals generated in the or each sensor winding.

10. A position encoder according to any preceding claim, wherein said at least one winding which is carried by said first member is arranged along said measurement path in a geometrically varying manner.

11. A position encoder according to claim 10, wherein said winding carried by said first member geometrically varies along the measurement path so that said sensor signal generated in said sensor winding varies substantially sinusoidally with the relative position between said first and second relatively movable members.

12. A position encoder according to any preceding claim, wherein said magnetic field generator is operable to generate a magnetic field having a magnetic axis which lies at an angle to said film.

13. A position encoder according to claim 12, wherein said magnetic field generator is operable to generate a magnetic field having an axis which is substantially perpendicular to said film.

14. A position encoder according to any preceding claim, wherein said magnetic field generator is operable to generate a DC magnetic field.

15. A position encoder according to any preceding claim, wherein said winding carried by said first member comprises at least two loops of conductor which extend along the measurement direction and which are connected in series in a figure of eight arrangement.

16. A position encoder according to any preceding claim, comprising a plurality of sensor windings and wherein each sensor winding is provided adjacent to a different portion of said film of magnetisable material and is sensitive to the magnetisation state of the film adjacent the respective sensor winding.

17. A position encoder according to any preceding claim, wherein said film of magnetisable material has a high permeability and a low coercivity.

18. A position encoder according to any preceding claim, wherein said film of magnetisable material comprises at least one of: pure iron, nickel iron alloy, cobalt iron alloy, an amorphous alloy, nano-crystalline alloy or a silicon iron.

19. A position encoder according to any preceding claim, wherein said measurement path is linear.

20. A position encoder according to any of claims 1 to 18, wherein said measurement path is circular.

21. A position encoder according to any of claims 1

to 19, wherein said excitation and sensor windings extend along different measurement paths and wherein said processing circuit is operable to process the signals generated in said sensor winding to determine a multi-dimensional relative position between said first and second relatively movable members.

22. A position encoder comprising:

first and second members which are relatively movable along a measurement path;

an excitation winding and a sensor winding, at least one of which is carried by the first member;

a magnetic field generator carried by the second member and operable to generate a magnetic field which varies with position along the measurement path;

a film of magnetisable material which is located, in use, within said positionally varying magnetic field to cause the film to have a positionally varying magnetisation state along the measurement path;

wherein the excitation and sensor windings are arranged relative to said film so that a mutual electromagnetic coupling between them varies in dependence upon the positionally varying magnetisation state of said film of magnetisable material, so that when said excitation winding is energised with an excitation signal, a sensor signal is generated in said sensor winding that varies with the relative position between said first and second members;

an excitation circuit operable to generate an excitation signal having an excitation frequency for energising the excitation winding to cause the excitation winding to generate an excitation electromagnetic field; and

a processing circuit operable to process the sensor signal generated in the sensor winding which is

at substantially the same frequency as said excitation frequency, to determine a value indicative of the relative position between the first and second relatively movable members.

23. A position encoder comprising first and second relatively movable members;

an excitation winding and a sensor winding, at least one of which is carried by the first member;

a magnetic field generator carried by the second member and operable to generate a magnetic field which varies with position along the measurement path;

a film of magnetisable material located, in use, in said positionally varying magnetic field such that the film has a positionally varying magnetisation state along the measurement path;

an excitation circuit operable to generate an excitation signal for energising the excitation winding, to cause the excitation winding to generate a magnetic field which cyclically varies with time and which interacts with said film of magnetisable material in a non-saturating manner in the vicinity of said sensor winding, to generate a time varying magnetic field which varies with position along the film;

wherein said sensor winding is operable to sense positional variations of said time and positionally varying magnetic field to output a sensor signal in dependence thereon;

wherein the arrangement is such that relative movement of said first and second members causes a relative movement between said time and positionally varying magnetic field and said sensor winding, whereby said sensor signal output by said sensor winding varies with the relative position of said

first and second members; and

a processing circuit operable to process the sensor signal output by the sensor winding to determine a value indicative of the relative position between the first and second relatively movable members.

24. A position encoder comprising:

first and second members which are relatively movable along a measurement path;

an excitation winding and a sensor winding, at least one of which is carried by the first member;

a magnetic field generator carried by the second member and operable to generate a magnetic field which varies with position along the measurement path;

a film of magnetisable material which extends along the measurement path and which is located, in use, within said magnetic field to cause the film to have a positionally varying magnetisation state along the measurement path;

wherein the excitation and sensor windings are arranged relative to said film so that a mutual electromagnetic coupling between them varied in dependence upon the positionally varying magnetisation state of said film of magnetisable material, so that when said excitation winding is energised with an excitation signal, a sensor signal is generated in said sensor winding that varies with the relative position between said first and second members;

an excitation circuit operable to generate an excitation signal for energising the excitation winding to cause the excitation winding to generate an excitation electromagnetic field; and

a processing circuit operable to process the sensor signal generated in the sensor winding in

response to the energisation of said excitation winding, to determine a value indicative of the relative position between the first and second relatively movable members; and

wherein said excitation circuit and said excitation winding are arranged so that said excitation electromagnetic field does not magnetically saturate the film of magnetisable material in the vicinity of said sensor winding.

25. A position encoder comprising:

first and second members which are relatively movable along a measurement path;

a film of magnetisable material which extends along the measurement path;

a magnetic field generator carried by the first member and operable to generate an in-homogeneity within the film of magnetisable material, the position of which varies with the relative position between said first and second members; and

a detector operable to detect the position of said in-homogeneity within said film to determine the relative position between the first and second members;

wherein said detector comprises an excitation winding and a sensor winding, at least one of which is carried by said second member, whose mutual coupling varies with the relative position between the in-homogeneity and said at least one of said excitation winding and said sensor winding.

26. A method of determining relative position of first and second relatively movable members, the method comprising the steps of:

providing a position encoder according to any

preceding claim;

causing said excitation circuit to generate said excitation signal for energising the excitation winding; and

processing the sensor signal induced in said sensor winding which varies in dependence upon the relative position of the first and second members, to determine a value indicative of the relative position between the first and second relatively movable members.